



TM

umc

**Living in a Modeled World**

# Building Analysis and Modeling at UMC



**David Park, Ph.D, PE, CEM, BEMP**  
BUILDING ANALYSIS & MODELING MANAGER

David couples **analysis with energy audits to identify energy efficiency measures** (EEMs) that are cost effective for owners' business goals. Driven to make a significant impact towards carbon reduction and sustainability, David enjoys studying and analyzing how building energy reduces utility and operational costs, making it a great investment for the future.



**Hailee Hammerquist, LEED Green Associate**  
BUILDING ANALYSIS & MODELING ENGINEER

Hailee is detail oriented, organized, and **passionate about sustainable design**. She loves tackling the complexity of our projects to ensure all the pieces fit efficiently together inside high-performing exteriors. Coming from West Virginia, Hailee is excited to experience all the outdoor adventures that the Seattle area has to offer.



## KNOWLEDGE

Why is our building so important?



## FORESIGHT

How can we design and build sustainable learning environments?

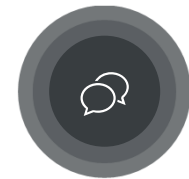
# OBJECTIVES

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## TIMELINESS

What is a “Model”?



## COLLABORATIVE

How can we understand our schools and buildings better?

# Why are Buildings so Important?

## 90%

of time is **spent indoors**



**We spend 90% of our time indoors.**

Over 21 of our 24 hours!

**IAQ can be worse than we think.**

"Concentrations of many VOCs\* are consistently higher indoors (up to ten times higher) than outdoors."

- EPA

\*volatile organic compounds

**And has real consequences.**

U.S. indirect costs, including missed work and lost productivity:

Asthma:  
**\$5 billion**

Allergic rhinitis (i.e. hay fever):  
**\$9.7 billion**

**But better IAQ improves productivity.**

Removing volatile organic compounds and enhancing ventilation improved problem solving in an office setting:

**288%**  
higher strategy scores

**299%**  
better information usage

## 40%

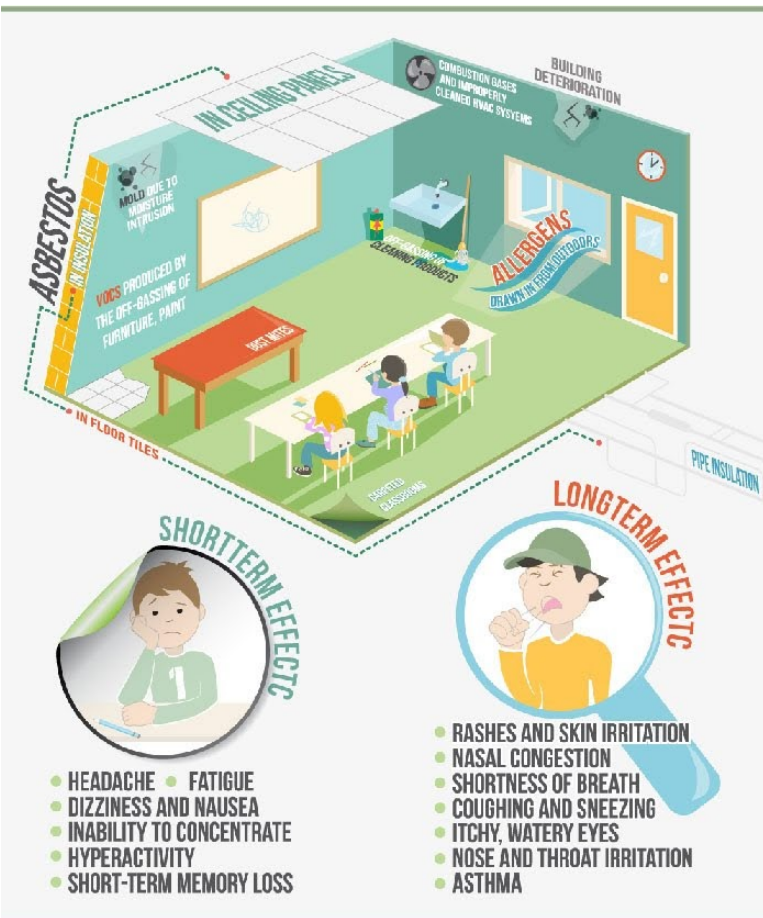
 of energy consumption...

14,600 million ton of **CO<sub>2</sub> emission**

Carbon sequestered by **241,412 million tree seedlings** grown for 10 years



# Adequate learning environment



# Possible Complications

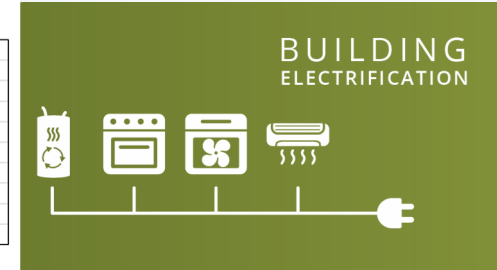
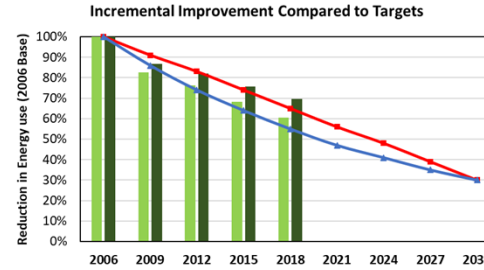
Stricter Targets Energy Code

Clean Buildings Standard

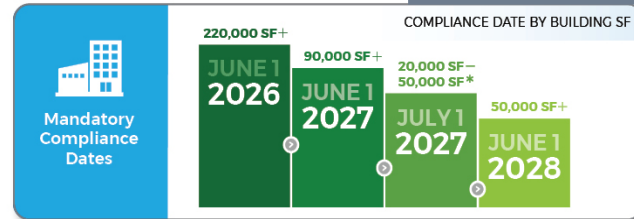
Seattle Building Emissions Performance Standard



## 1. Stricter Targets Energy Code

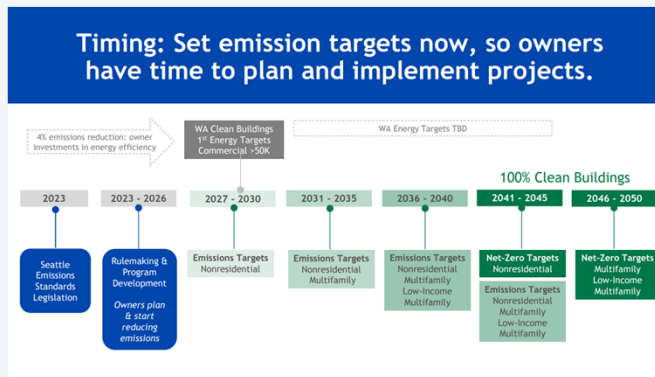


## 2. Clean Buildings Standard



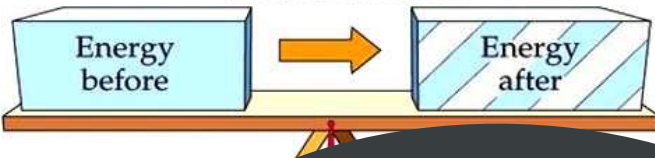
\*Buildings 20,000 SF – 50,000 SF must now submit their EUI per Energy Star Portfolio Manager along with their Energy Management Plan, Operation & Maintenance Program, and Capital Management Plan by July 1, 2027

## 3. Seattle Building Emissions Performance Standard



# 1<sup>ST</sup> LAW of Thermodynamics

The First Law of Thermodynamics  
Energy transformation



**Checking point**

Are we minimizing energy loss?  
Are we minimizing waste?

ENERGY INPUT: Total Energy Consumption

WASTE

ENERGY LOSS:  
Inefficiency

ENERGY NEED:  
Building

# Do we know our buildings?



Important Information pse.com | f t o v i

**JENNY PUGET**  
Serving: 12345 POWER AVE S, Bellevue

### Your Usage Information



	Last Year	This Year
Average daily kilowatts	19.67	32.81
Average daily cost	\$2.07	\$3.25
Days in billing cycle	30	32
Average temperature	66°F	66°F



	Last Year	This Year
Average daily therms	0.73	1.46
Average daily cost	\$1.21	\$1.93
Days in billing cycle	30	32
Average temperature	66°F	66°F

Issued: July 15, 2018  
**Account Number: 200012345678**  
**DUE DATE August 4, 2018**  
**TOTAL DUE \$165.64**

### Your Account Summary

**Previous Charges:**  
 Amount of Your Last Bill (dated 6/13/2018) \$ 137.78  
 Payment received 7/3/2018 – Thank you! -137.78

**Past Due Amount \$ 0.00**

**Current Charges:**  
 Electric Charges \$ 103.95  
 Natural Gas Charges 61.69

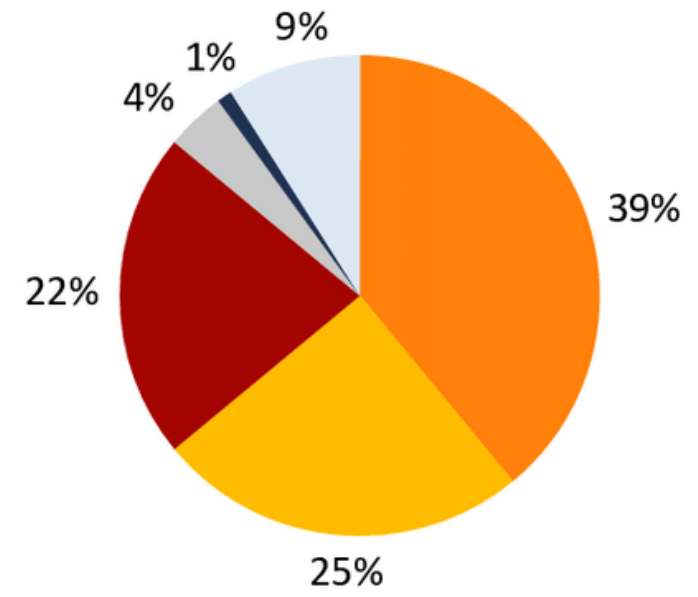
**Total Current Charges \$ 165.64**

*Total includes current and past due charges* **Total \$ 165.64**

Late Payments | A late payment fee of 1% per month will apply to past due charges, if any, and amounts unpaid more than 10 business days after the statement due date. Amounts will be considered delinquent if payment is not received on or before the due date.

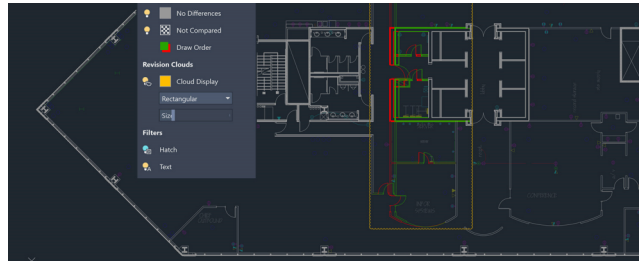
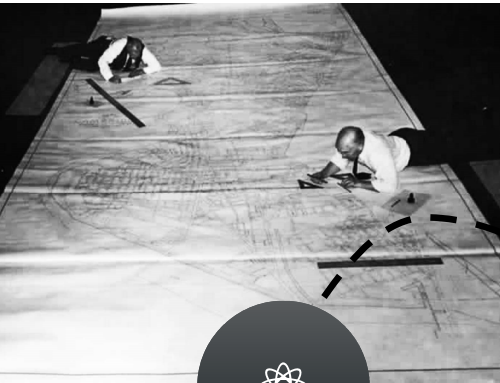
**Monthly Energy Tip**  
 Save money and stay cool this summer. Add insulation to make your home more energy efficient throughout the year.

**How to reach us**  
 Email: [customercare@pse.com](mailto:customercare@pse.com)  
 Customer Service: 1-888-225-5773 | TTY: 1-800-962-9498  
 Hours: 7:30 a.m. – 6:30 p.m. M – F | TRS: 1-866-831-5161  
 Puget Sound Energy, P.O. Box 91269, Bellevue, WA 98009  
**24 Hour Emergency and Outage line: 1-888-225-5773**

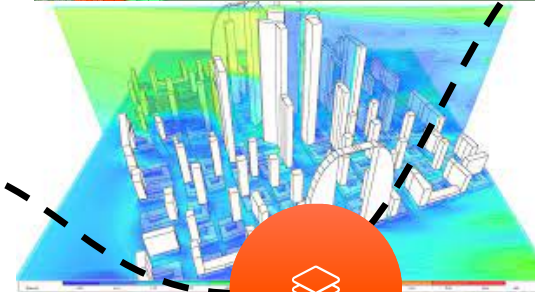
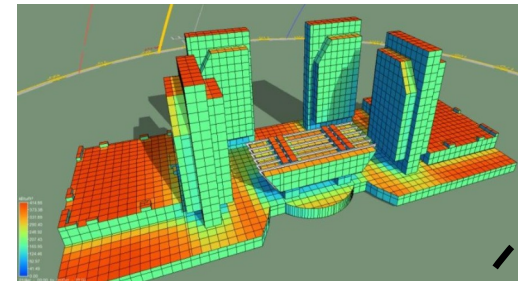




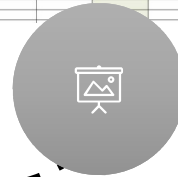
# Technological Evolution



ENERGY CONSUMPTION CALCULATOR										
Location	My House		Maximum consumption per day		11.33 kWh					
Cost/kWh	0.75 \$		Average consumption per day		3.28 kWh					
Total Rating/Hour	3,949.00 Watt		Total Consumption per month		293.47 kWh					
© 2016 - Exceltemplate.net			Total Monthly Cost		220.50 \$					
No	Appliances	Rating [W]	Hourly Usage per Day	# of Units	Consumption per Day	Day Frequency Usage per Week	Consumption per Week	Day Frequency Usage per Month	Consumption per Month	Monthly Cost
1	Television - Samsung	150.00	5.0	1	0.75	7.0	5.25	30.0	23.50	16.88
2	Air Conditioner - Panasonic	480.00	6.0	1	2.88	7.0	20.16	30.0	86.40	64.80
3	Air Conditioner - Panasonic 2	480.00	1.0	1	0.40	7.0	2.80	30.0	12.00	9.00
4	WiFi Modem	10.00	24.0	1	0.24	7.0	1.68	30.0	7.20	5.40
5	Cable TV Setup Box	25.00	24.0	1	0.60	7.0	4.20	30.0	13.50	10.13
6	Internet Modem	30.00	24.0	1	0.24	7.0	1.68	30.0	7.20	5.40
7	Mobile Phone Charger - Samsung	3.00	3.0	1	0.05	7.0	0.06	30.0	0.27	0.20
8	Microwave	600.00	0.5	1	0.30	5.0	1.50	9.00	9.00	6.75
9	Refrigerator	300.00	24.0	1	2.52	7.0	17.64	30.0	75.60	56.70
10	Coffee Maker	600.00	1.0	1	0.60	5.0	3.00	20.0	12.00	9.00
11	Toaster	600.00	0.5	1	0.30	5.0	1.50	20.0	6.00	4.50
12	Laptop	50.00	3.0	1	0.15	7.0	1.05	30.0	4.50	3.38
13	Electric Iron	400.00	3.0	1	1.20	2.0	2.40	8.0	9.60	7.20
14	Washing Machine	500.00	1.0	1	0.50	2.0	1.00	8.0	4.00	3.00
15	LED Light Bulb - 7	7.00	10.0	4	0.28	7.0	1.96	30.0	5.40	6.30
16	LED Light Bulb - 9	9.00	10.0	4	0.36	7.0	2.52	30.0	10.80	8.10
17										
18										
19										
20										



Now



1990-2000ish



Pre 1970

# What is Building Energy Model and CFD?

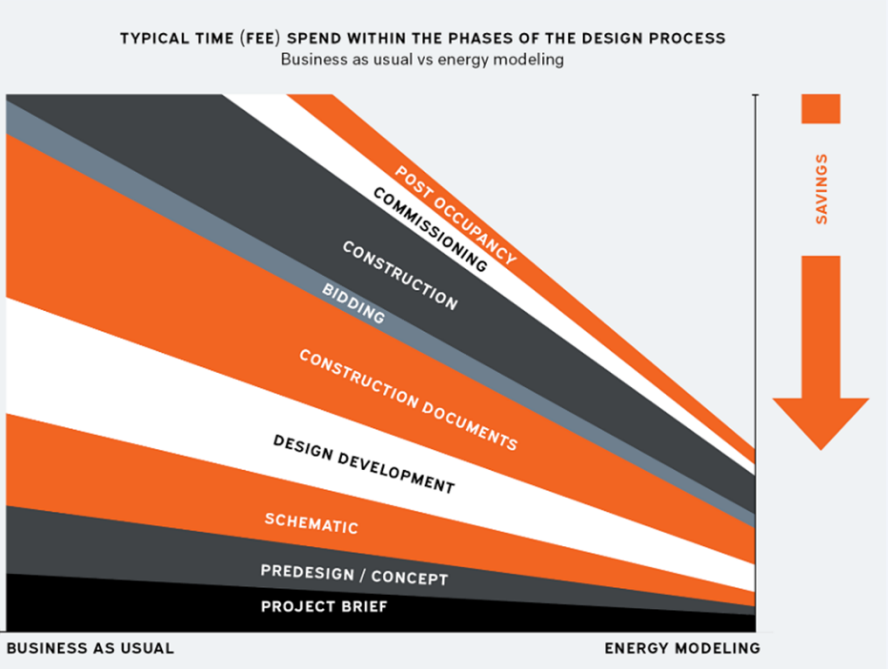
## BUILDING ENERGY MODELING

The practice of using computer-based simulation software to perform a detailed analysis of energy use and energy-using systems

## COMPUTATIONAL FLUID DYNAMICS (CFD)

Mathematically predicting physical fluid flow by solving the governing equations using simulations

# Modeling Capabilities



CAMPUS + DISTRICT ENERGY PLANNING



CARBON + ENERGY PLANNING



CODE COMPLIANCE



CLEAN BUILDINGS STANDARD COMPLIANCE



COMPUTATIONAL FLUID DYNAMICS (CFD)



DEEP ENERGY + CARBON RETROFITS



ENERGY ANALYSIS



GREEN BUILDING RATING SYSTEM CERTIFICATION

# Why You Should Consider Modeling

**Energy Modeling Enables a Cycle of Benefits Throughout the Design Process**



**Aggressive targets and code**

**Smart and efficient decisions**

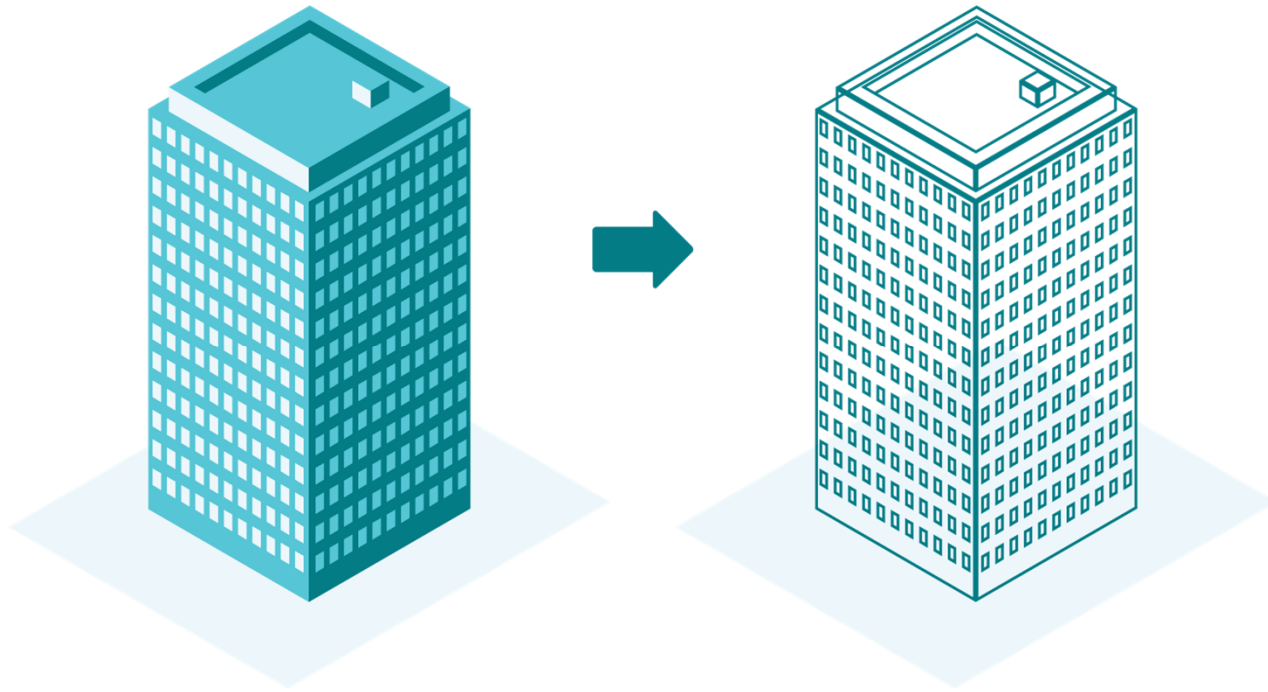
**Reduced Operating and Cost**

**Deeper knowledge of building design**

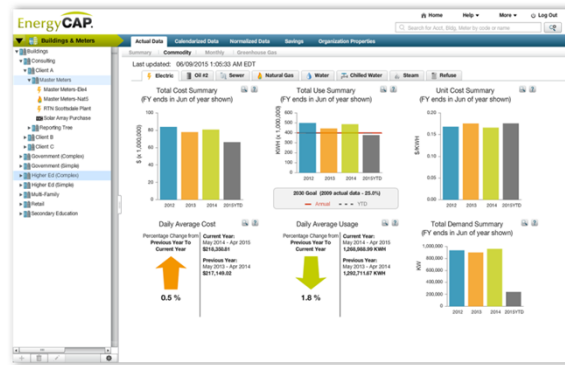
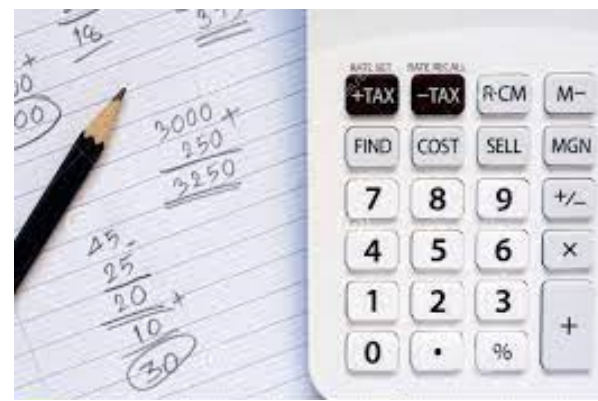
**Sustainable Design and Solution**

**Working together**

# Definition of a Model



# Available Models and Tools



### Wire to Water Energy Calculator

**REQUIRED DATA**

	PUMP 1	PUMP 2
Pump Operation - Hours / Day	8	8
Pump Operation - Days / Year	365	365
Pump Flow - GPM	1000	1000
Pump Head - Feet	88	88
Pump Efficiency - %	80%	74%
Motor Efficiency - %	94.1%	87.5%
Energy Cost in \$/KWH	\$0.10	\$0.10

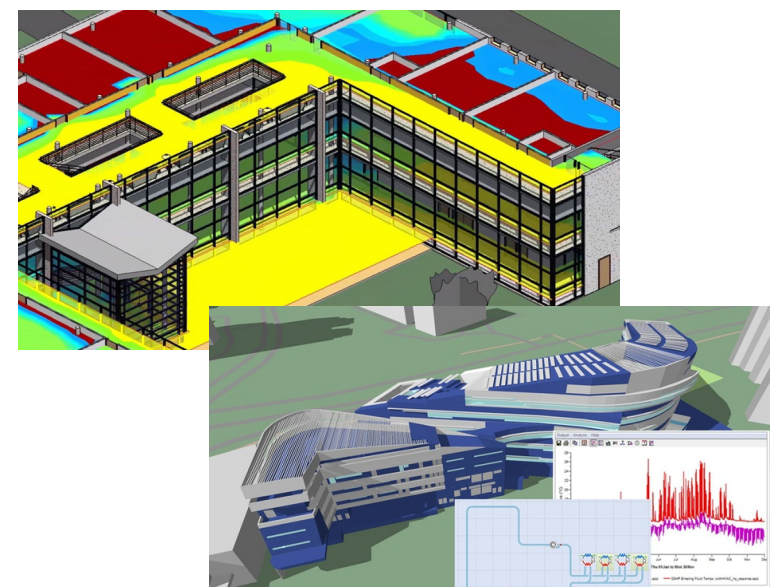
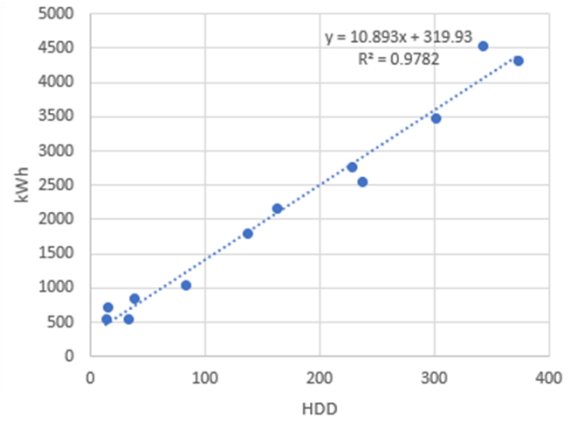
**RESULTS**

	PUMP 1	PUMP 2
BHP At Design Point	27.8	30.0
Wire to Water Efficiency - %	75%	65%
Annual Energy Cost	\$6,430.28	\$7,476.00
KW Per 1000 Gallons Pumped	0.367	0.427
Cost Per 1000 Gallons Pumped	\$0.037	\$0.043

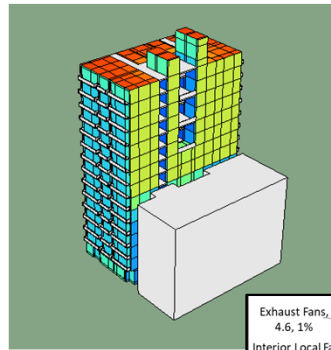
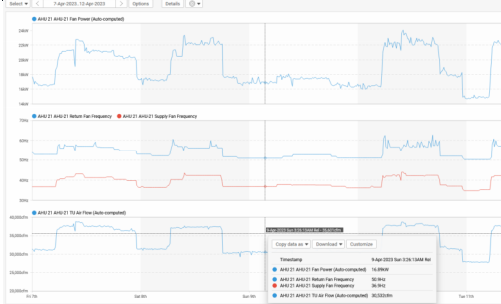
**PAYBACK**

Annual Savings - \$\$	\$1,045.73
Annual Savings - %	13.99%
Cost of Pump 1	\$9,000.00
Cost of Pump 2	\$7,200.00
Payback - Years	1.7

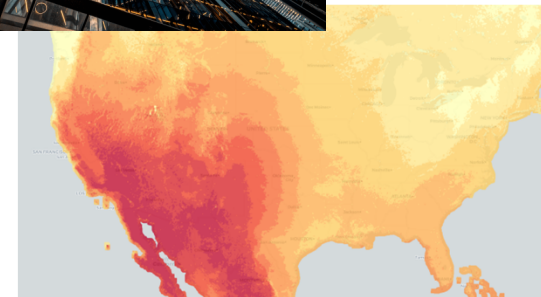
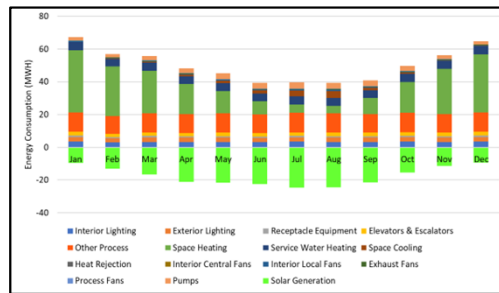
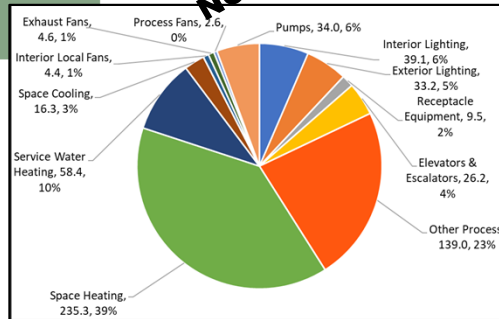
*Note: When comparing two pumps, place the lower efficiency pump/motor in the Pump 2 column.*

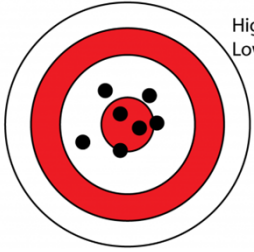
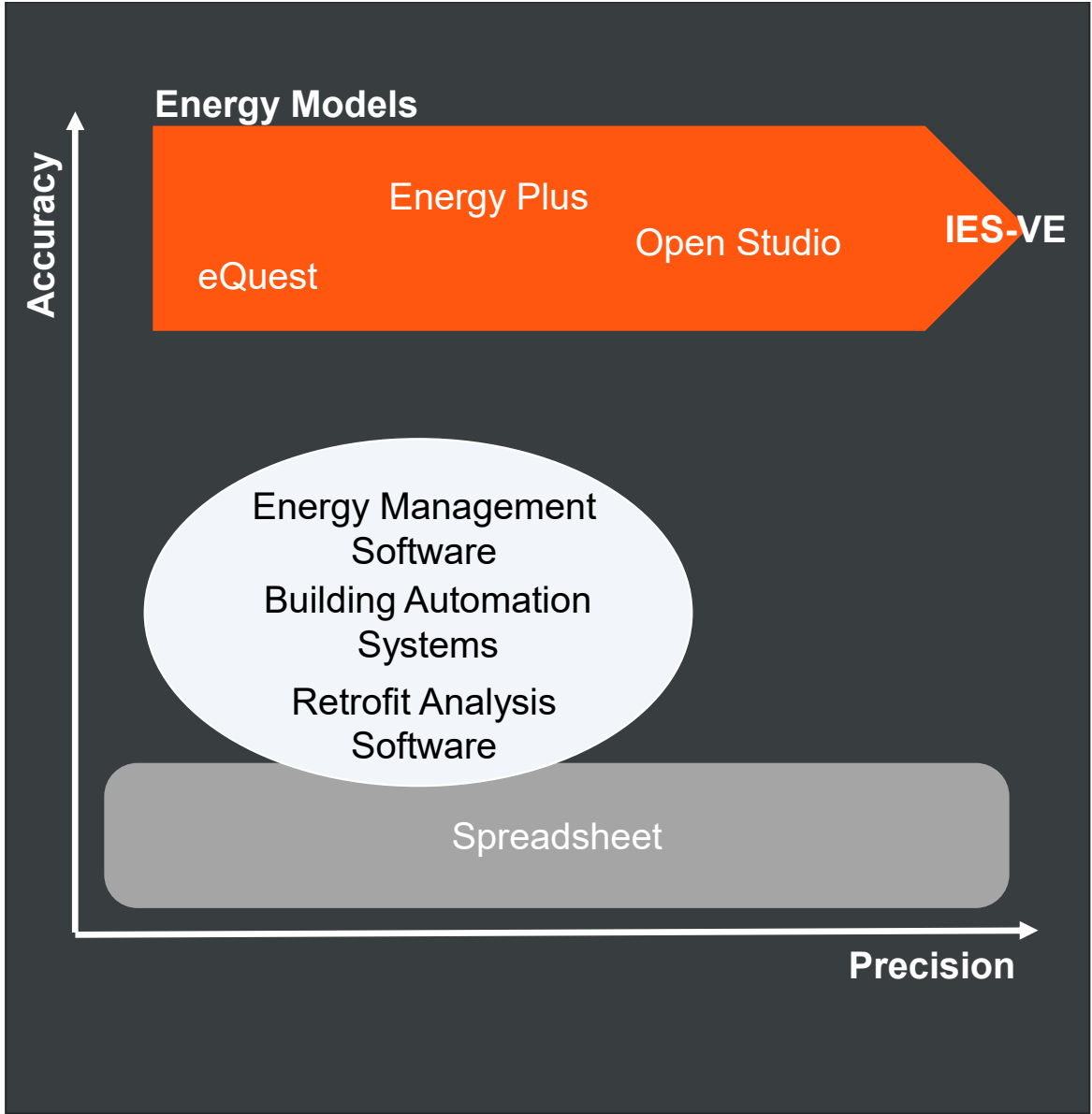


# Limitation and Challenges

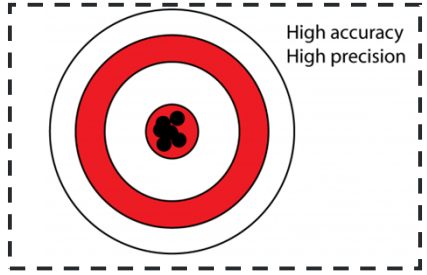


High accuracy  
High precision

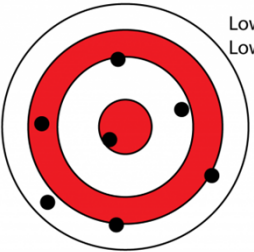




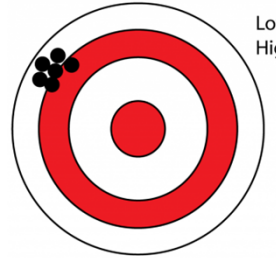
High accuracy  
Low precision



High accuracy  
High precision



Low accuracy  
Low precision



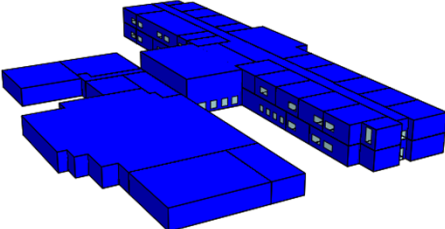
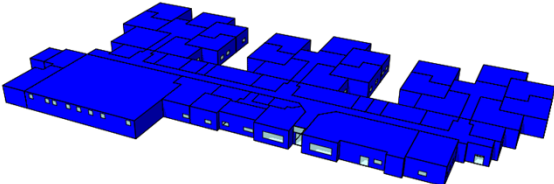
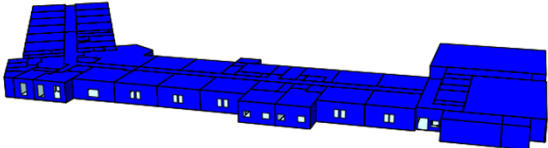
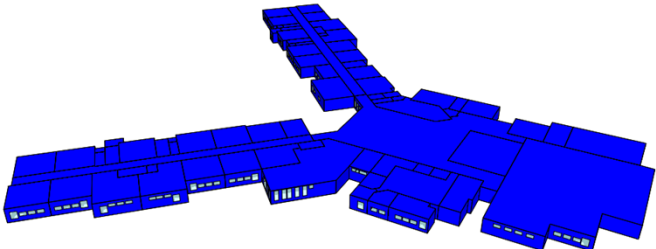
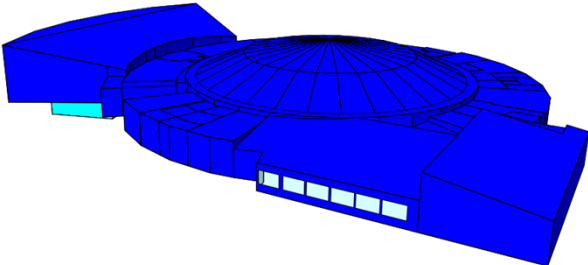
Low accuracy  
High precision



# Sample: School District

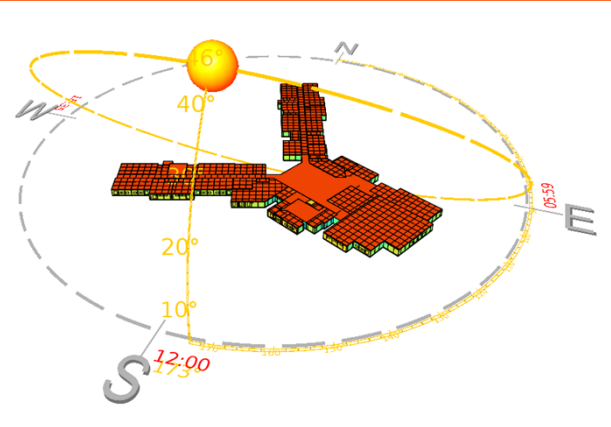
**Objective**

Develop energy management plan to meet clean building standards and decarbonization goals



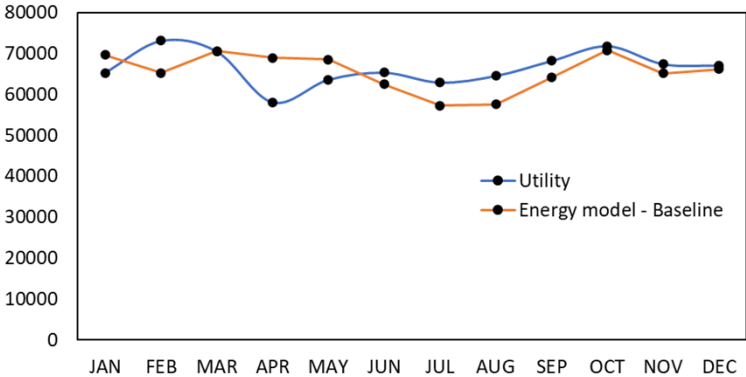
# High accuracy and precision

## CASE STUDY Middle School

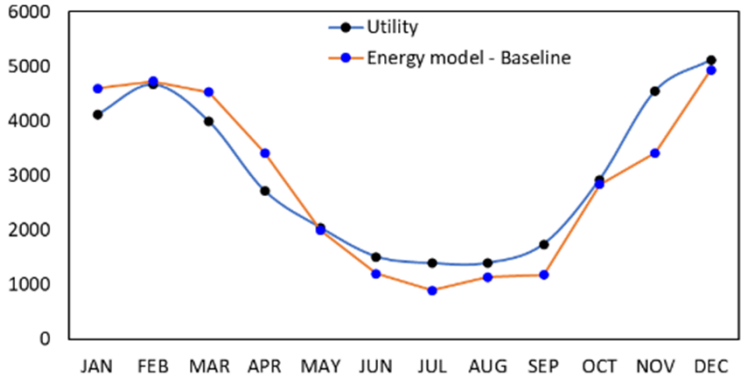


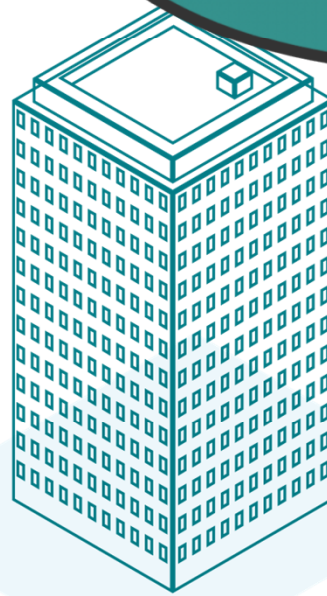
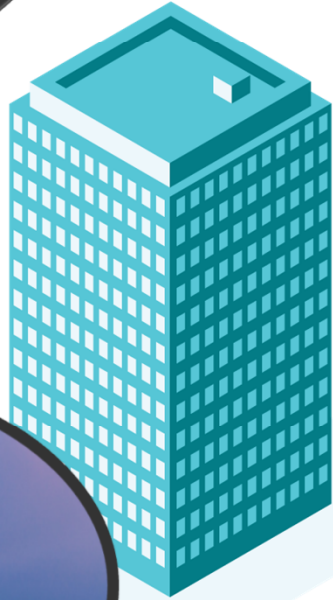
<4% Error

Electricity Usage (KWH)



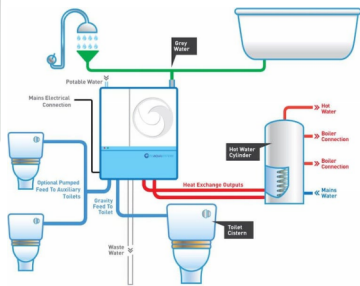
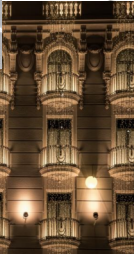
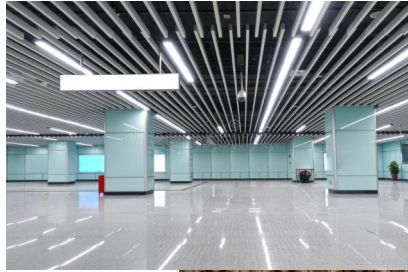
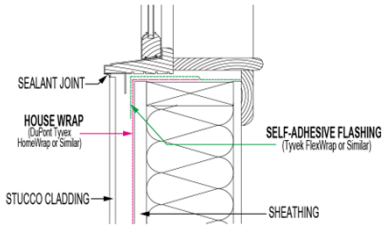
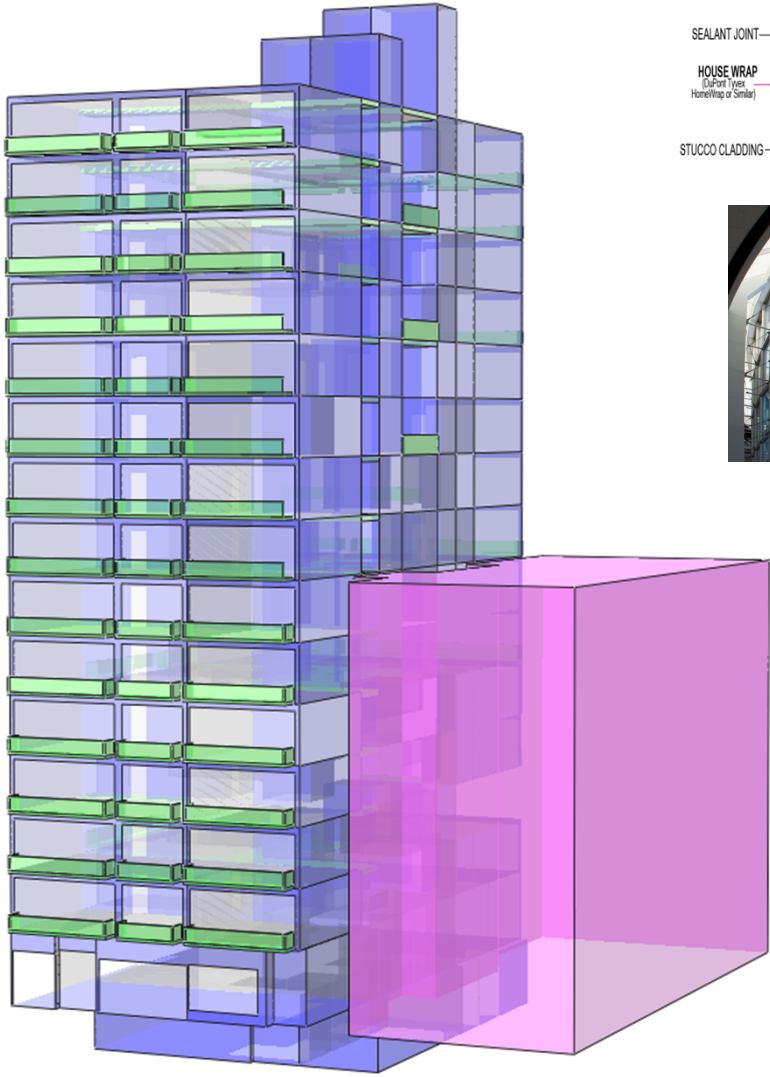
Natural Gas Usage (Therm)



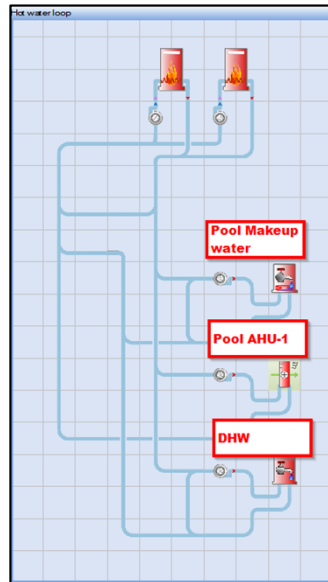
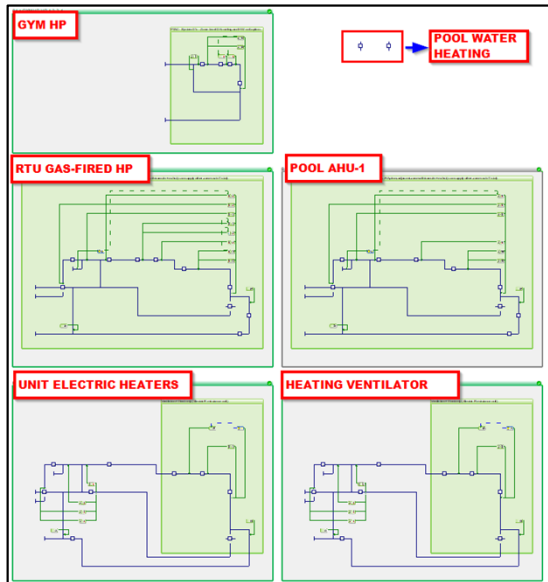
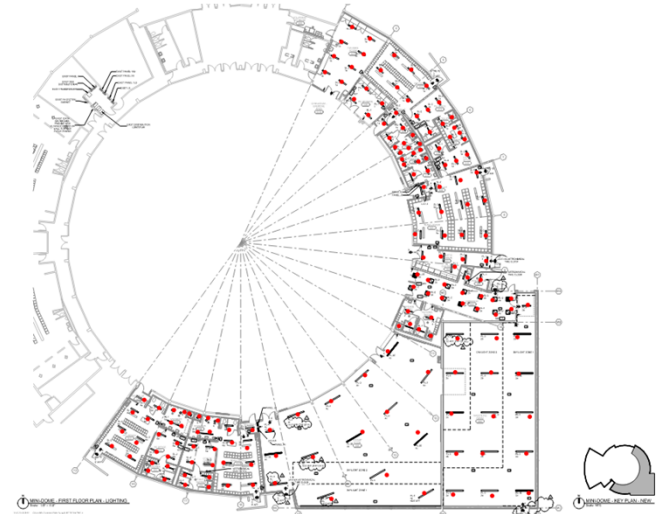
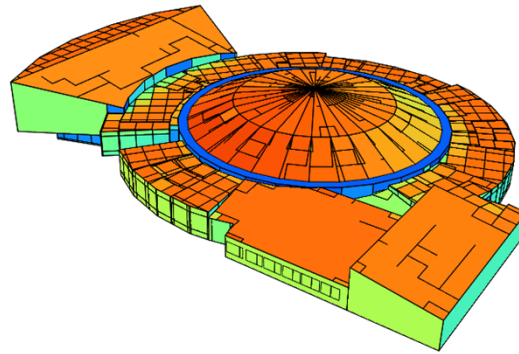




# The Importance of *Breaking Barriers*



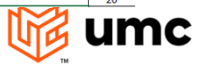
# ENERGY MODEL - Mini-Dome



## Lighting Take-off

Seq. #	Building	Location	Existing Fixture Type	Existing Fixture Quantity
1132	Mini Dome	Entry	Mercury Vapor Canopy Light 100W	18
1133	Mini Dome	Entry	T8 Prismatic Troffer 1x4 (2) 4' Lamps	2
1134	Mini Dome	Hallway	T8 Surface Mounted Parabolic Fixture 1x4 (2) 4' Lamps	2
1135	Mini Dome	Custodian	T8 Wrap Fixture 1x4 (2) 4' Lamps	2
1136	Mini Dome	Storage 905	T8 Wrap Fixture 1x4 (2) 4' Lamps	3
1137	Mini Dome	Mens Restroom	T8 Surface Mounted Parabolic Fixture 1x4 (2) 4' Lamps	5
1138	Mini Dome	Womens Restroom	T8 Surface Mounted Parabolic Fixture 1x4 (2) 4' Lamps	5
1139	Mini Dome	Concessions	T8 Surface Mounted Parabolic Fixture 1x4 (2) 4' Lamps	8
1140	Mini Dome	Concessions Hallway	T8 Surface Mounted Parabolic Fixture 1x4 (2) 4' Lamps	2
1141	Mini Dome	Main Gym	T8 Highbay Fixture 2x4 (6) 4' Lamps	68
1142	Mini Dome	Main Gym	T8 Surface Mounted Parabolic Fixture 1x4 (2) 4' Lamps	15
1143	Mini Dome	Poolside Hallway	T8 Surface Mounted Parabolic Fixture 1x4 (2) 4' Lamps	22
1144	Mini Dome	Poolside Hallway	T8 Surface Mounted Parabolic Fixture 2x2 (2) U Bend Lamps	1
1145	Mini Dome	Poolside 927 Classroom	T8 Wrap Fixture 1x4 (2) 4' Lamps	20

Lighting Audit





## Natatorium Design Guide

# Natatorium Design Conditions

- Dry Bulb Temperature: 75°F-85°F
- Relative humidity: 50%-60%
- Pool water temperature: ~80°F
- Ventilation: ASHRAE 62.1-Pool spaces
- Supply air: 6-8 Air changes
- Chloramines and corrosion

$$ER = 0.1 \times A \times AF (P_w - P_{dp})$$

ER = evaporation Rate of water, lb/h

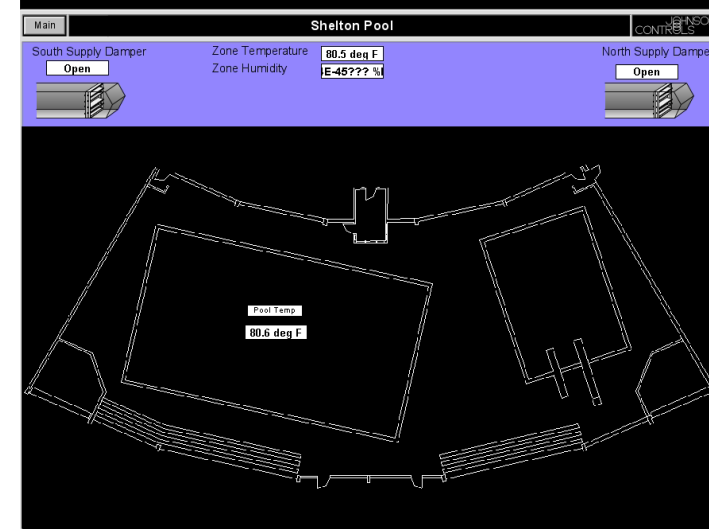
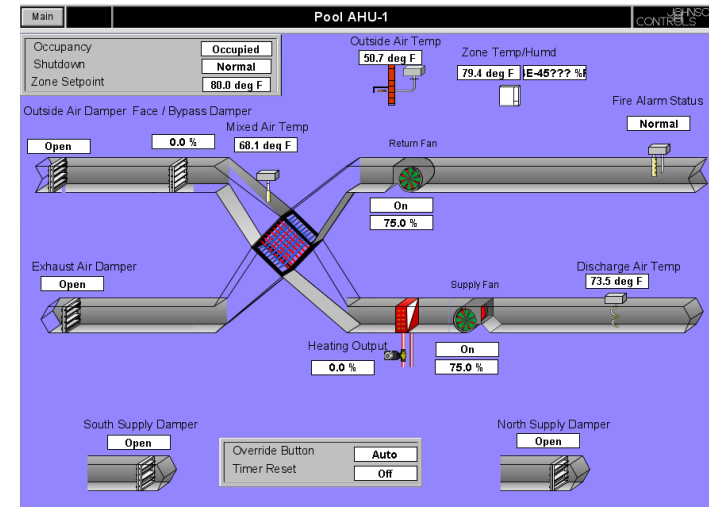
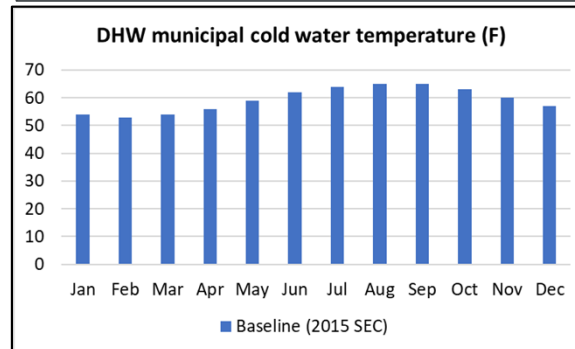
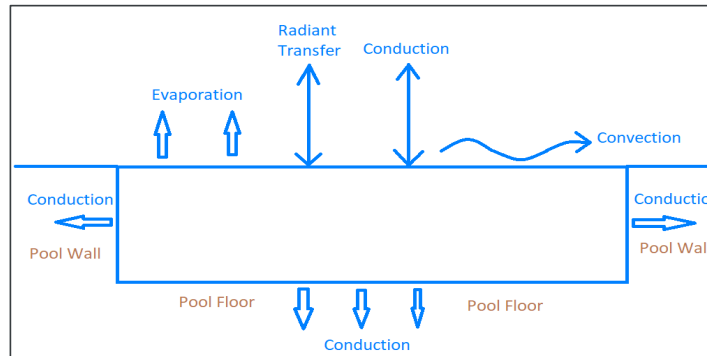
A = area of pool water surface, ft<sup>2</sup>

AF = Activity Factor (see Table 2)

P<sub>w</sub> = saturation vapor pressure at water surface, in. Hg

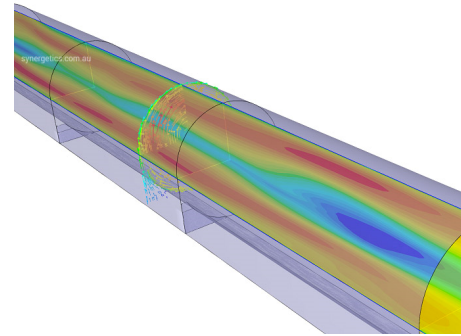
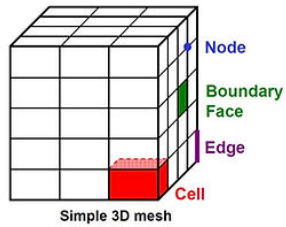
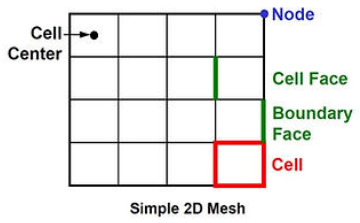
P<sub>dp</sub> = partial vapor pressure at room dew point, in. Hg

Type of Pool	Activity Factor
Elderly swim	0.65
Fitness club – Aquafit	0.65
Hotel	0.8
Institutional - School	0.8 – 1.0
Physical Therapy	0.65
Public / YMCA	1.0
Residential	0.5
Swim Meet	0.65
Wave Pool	1.5 – 2.0
Whirlpool	1.0

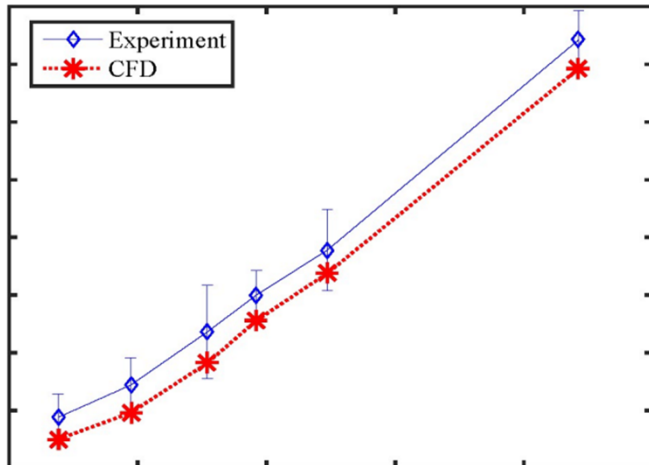
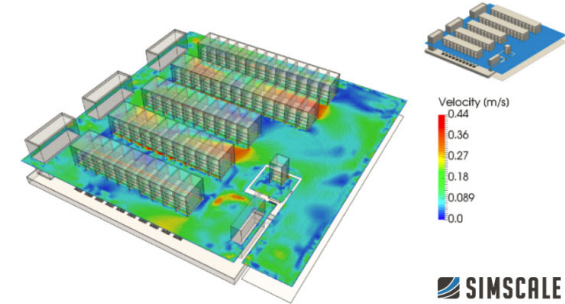


# Computational Fluid Dynamics (CFD)

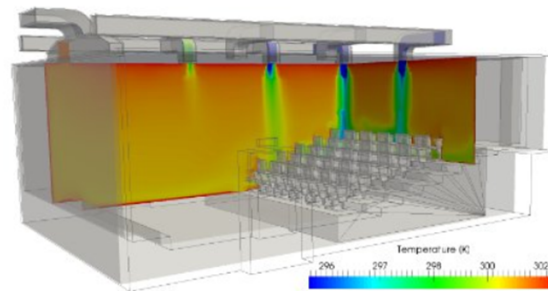
Simulates fluid flows and analyze the flow characteristics using numerical methods



Data Center Cooling

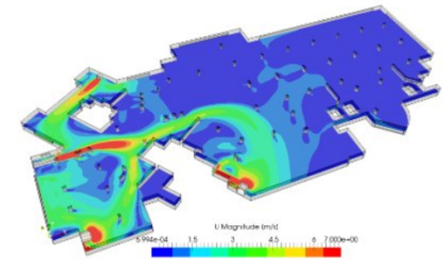


Tunnel Ventilation



Thermal Comfort

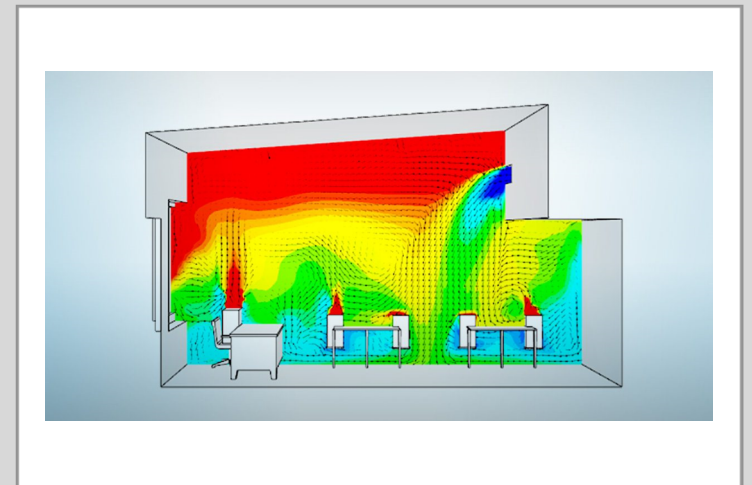
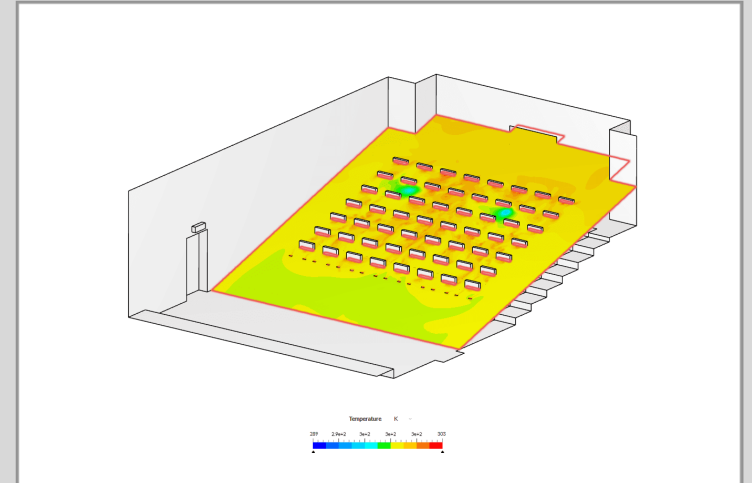
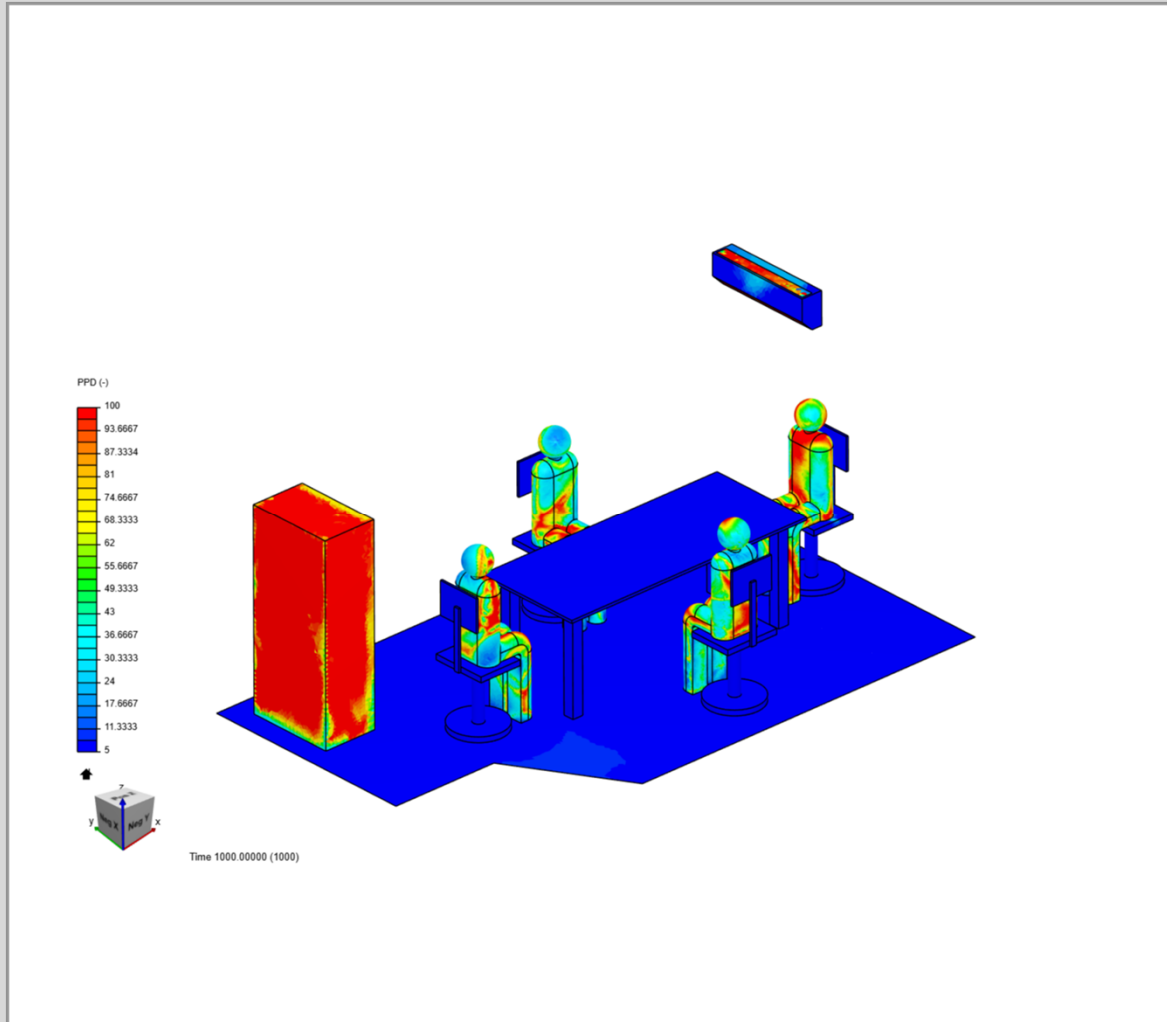
Data Center Cooling



Contaminant Control







# Breaking Barriers

## DIVERSITY

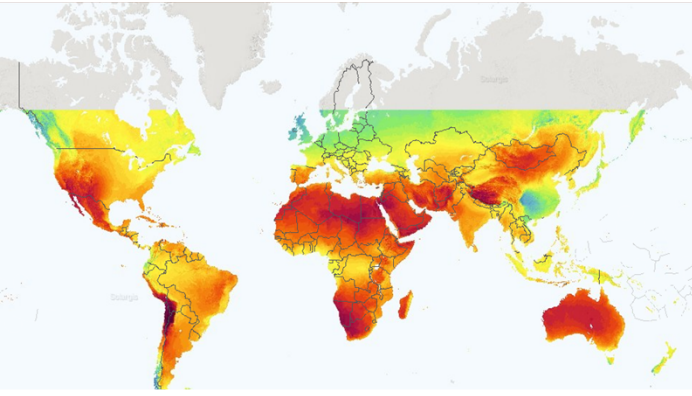


## EDUCATION



## COLLABORATION

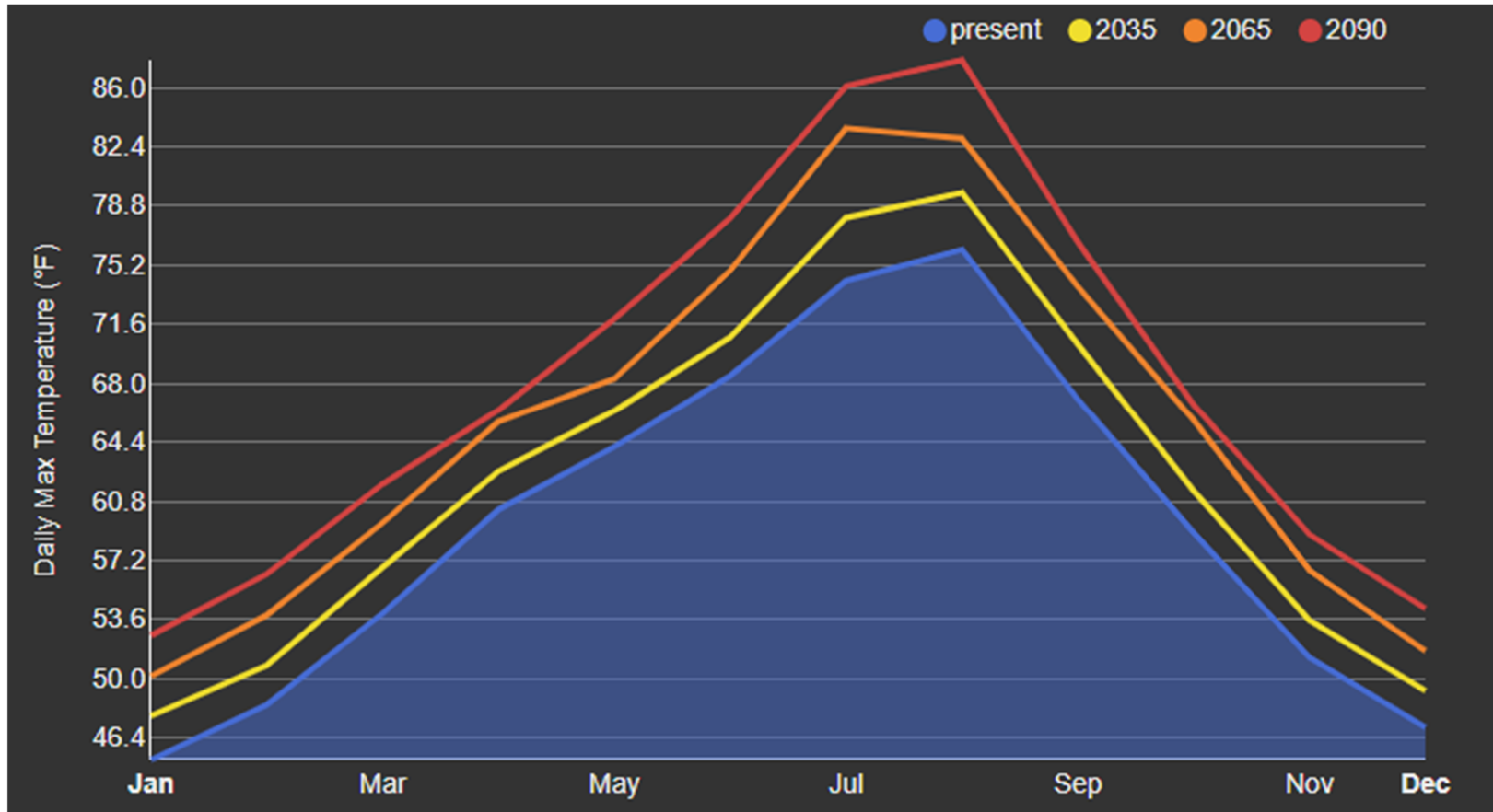




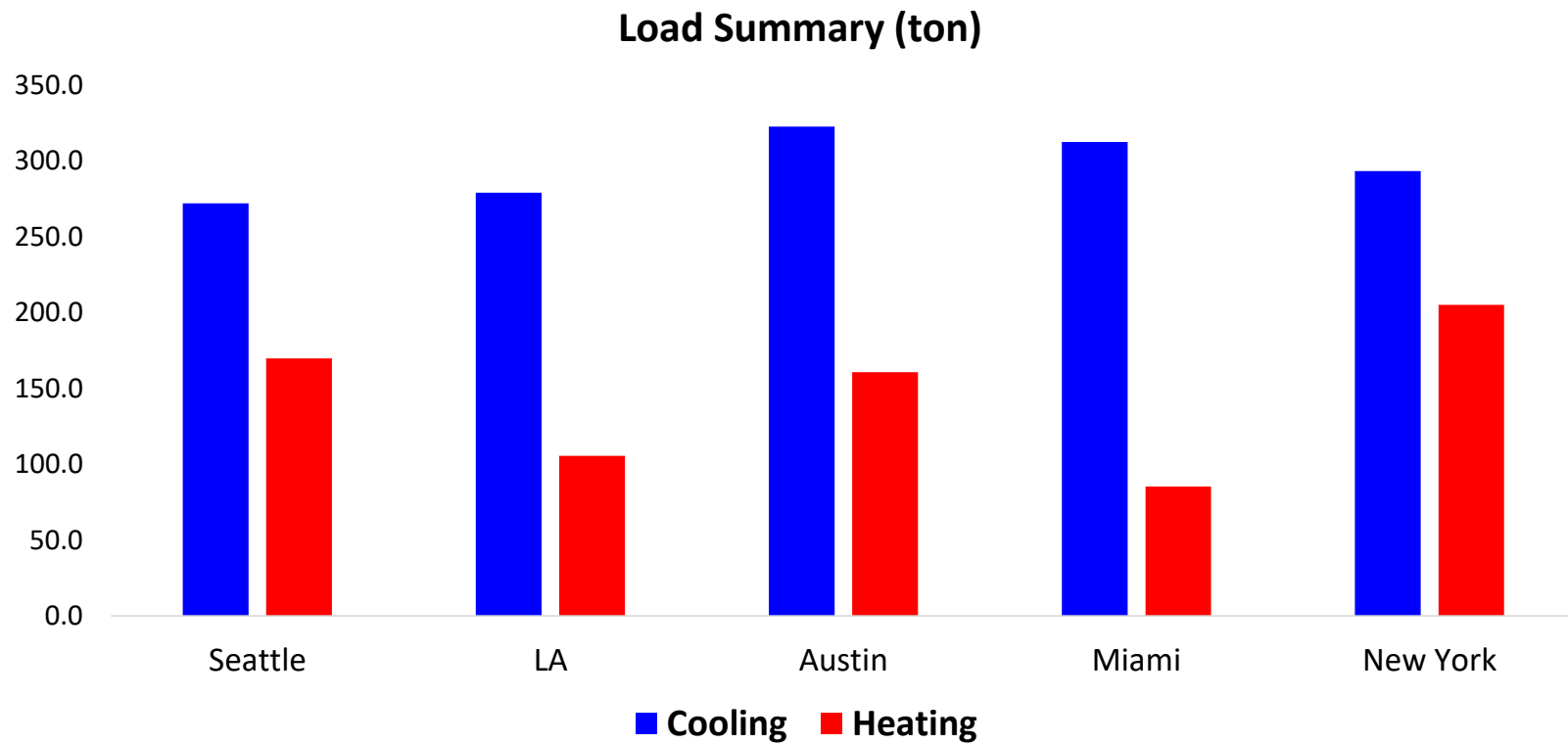
# Linking Buildings to Place

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# Climate Change

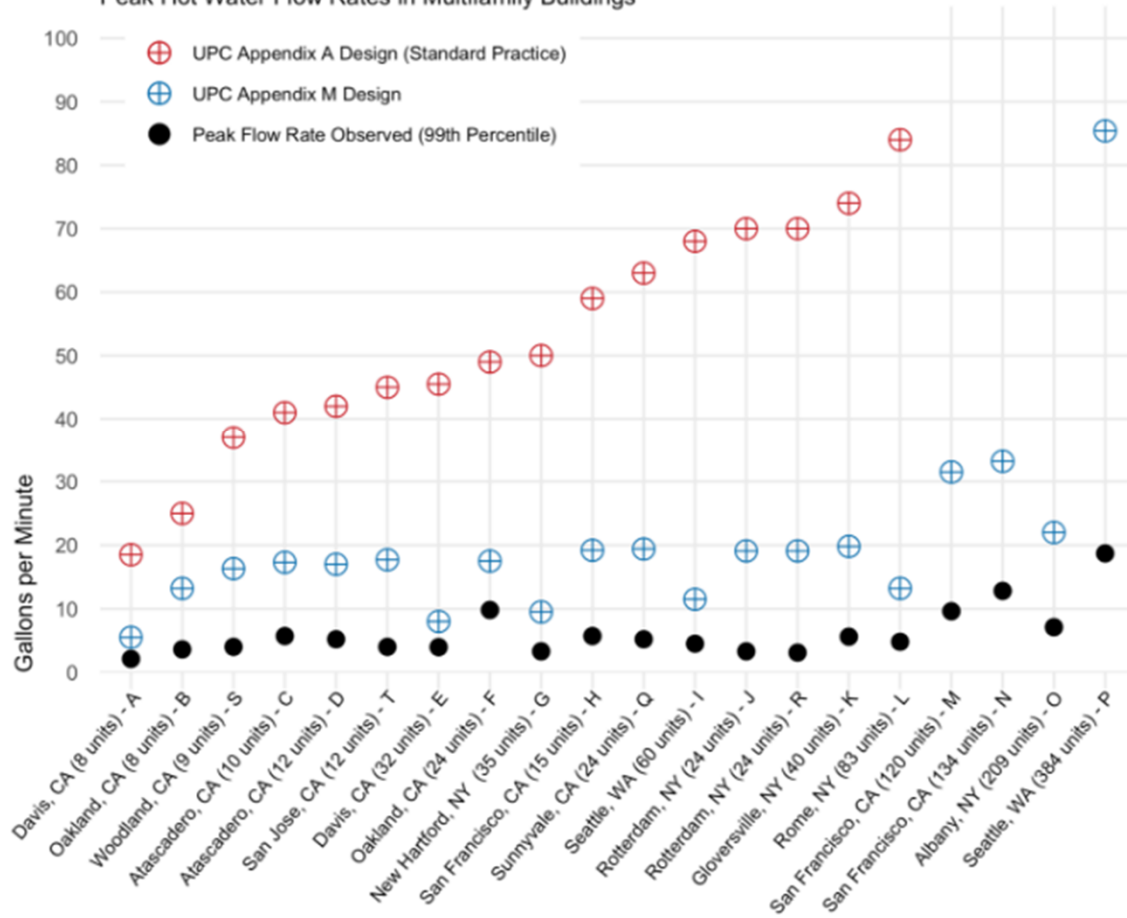


# Same Building, *Different Location*



# Oversizing Problem

**Comparing Design Predictions to Actual Peak Flow Rates**  
Peak Hot Water Flow Rates in Multifamily Buildings



# Importance of Topography

## *Initial Load Calculation of ~500-ton Cooling*

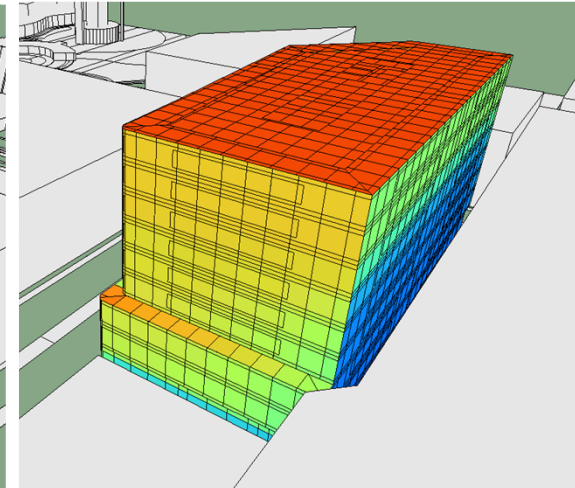
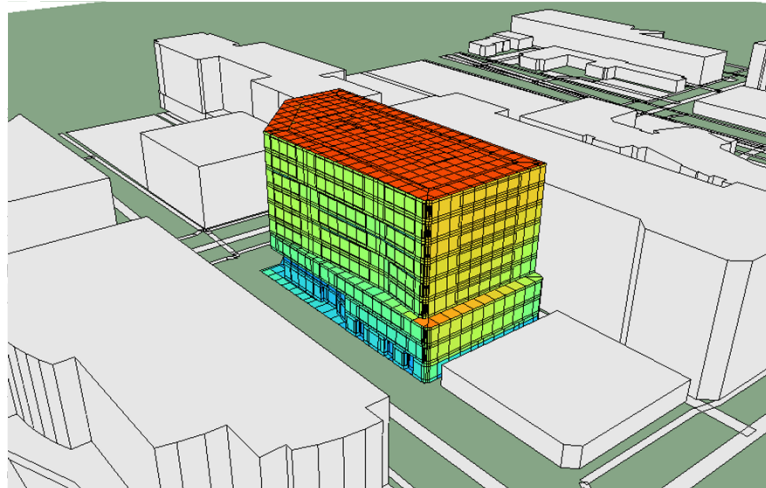
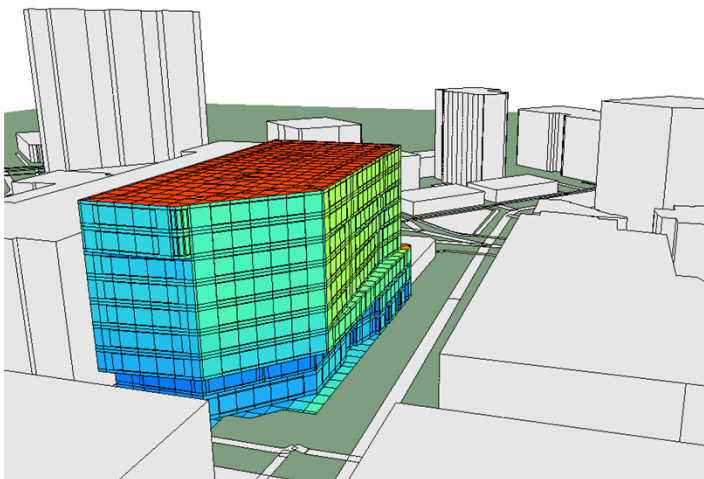
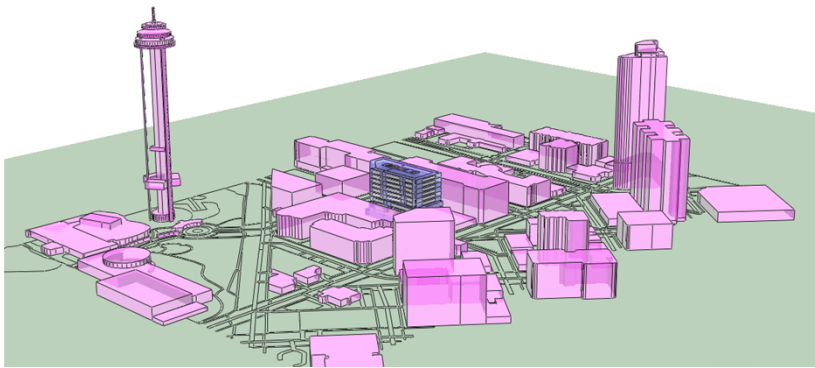
### **PROBLEM**

- The project does not have enough roof space for bigger chillers
- Traditional load calculation tool is not able to consider shading effect accurately
- Initial load is peak of peaks, not building peaks

### **SOLUTION**

#### *Implemented shading analysis*

- Peak of peak: 490 ton
- Building Peak: 450 ton



# Importance of Community Engagement



**Behavioral  
Changes**



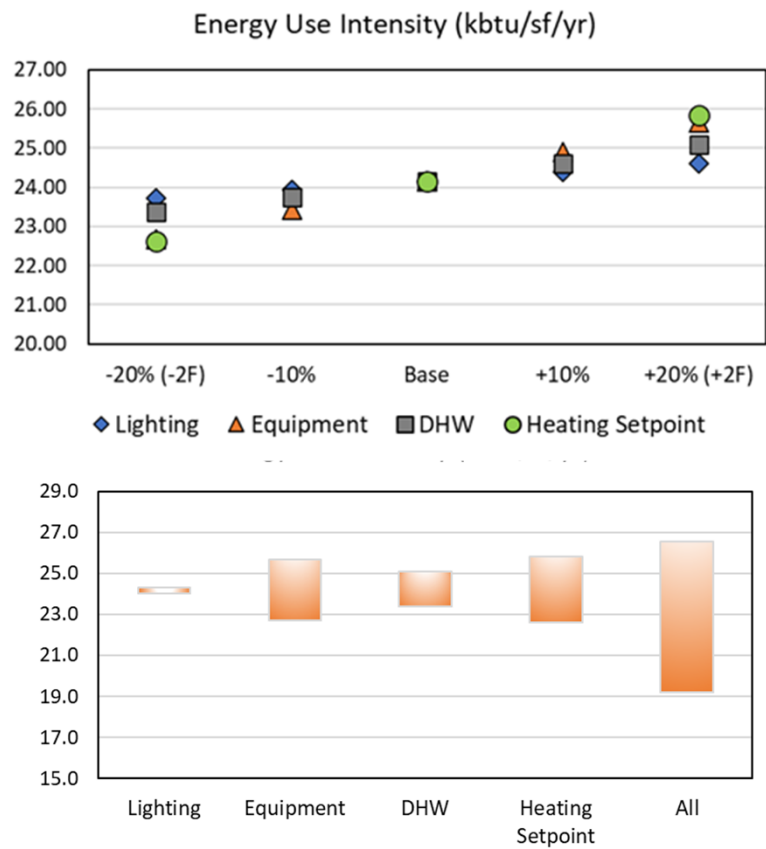
**Data Collection and  
Validation**



**Long-Term Planning**



# Sensitivity Analysis for New construction



# Data Collection

Schools	Baseline Schedule
School A	Damper Schedule: 6 am – 9 pm Heating occ./unocc.: 69°F/66°F Cooling occ./unocc.: 72°F/80°F
School B	Damper Schedule: 4 am – 6 pm Heating occ./unocc.: 69°F/66°F Cooling occ./unocc.: 72°F/80°F
School C	Damper Schedule: 4 am – 6 pm Heating occ./unocc.: 69°F/66°F Cooling occ./unocc.: 74°F/80°F
School D	Damper Schedule: 4 am – 6 pm Heating occ./unocc.: 69°F/66°F Cooling occ./unocc.: 72°F/80°F
School E	Damper Schedule: 6 am – 9 pm Heating occ./unocc.: 69°F/66°F Cooling occ./unocc.: 72°F/80°F

## School Hours

### School Hours

School starts at 8:00 am and ends at 2:35 pm

### Office Hours

Office hours during the school year are 7:30 am until 3:30 pm.

### Friday Early Release for Professional Learning Time

School starts at 8:00 and ends at 1:05

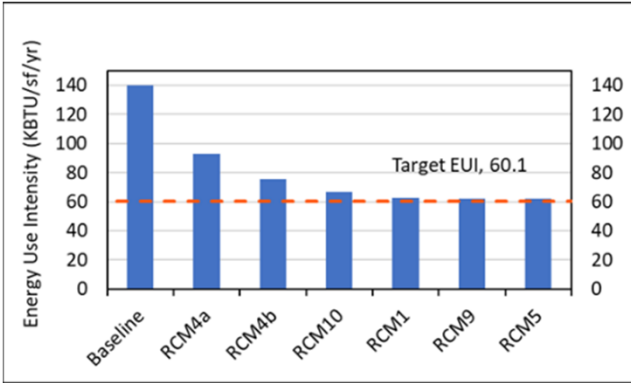
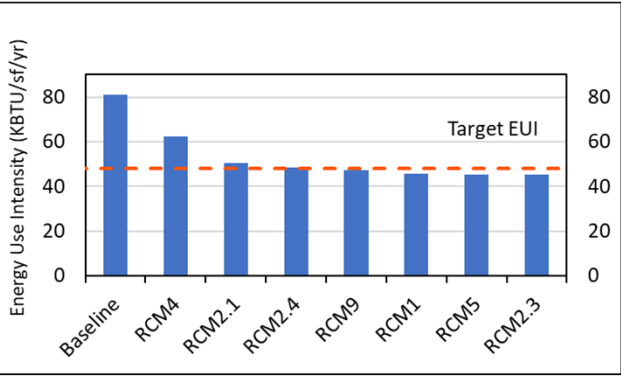
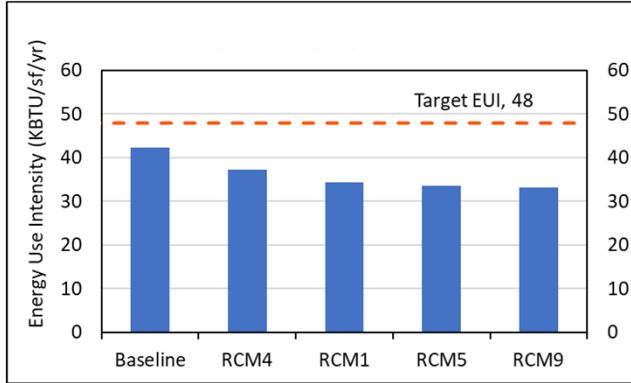
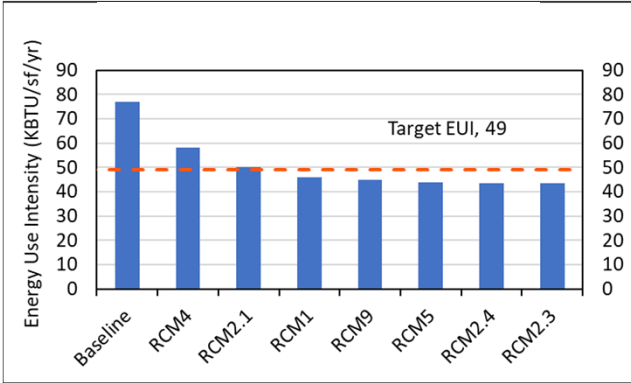
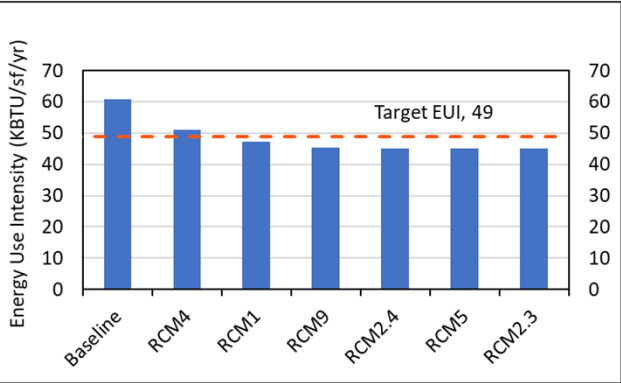
### Early Release - 3 Hours (Conferences and other days)

School starts at 8:00 and ends at 11:35

### Late start for inclement weather (2 hour late start)

School starts at 10:00 and ends at 2:35

# Evaluating EEM Sample



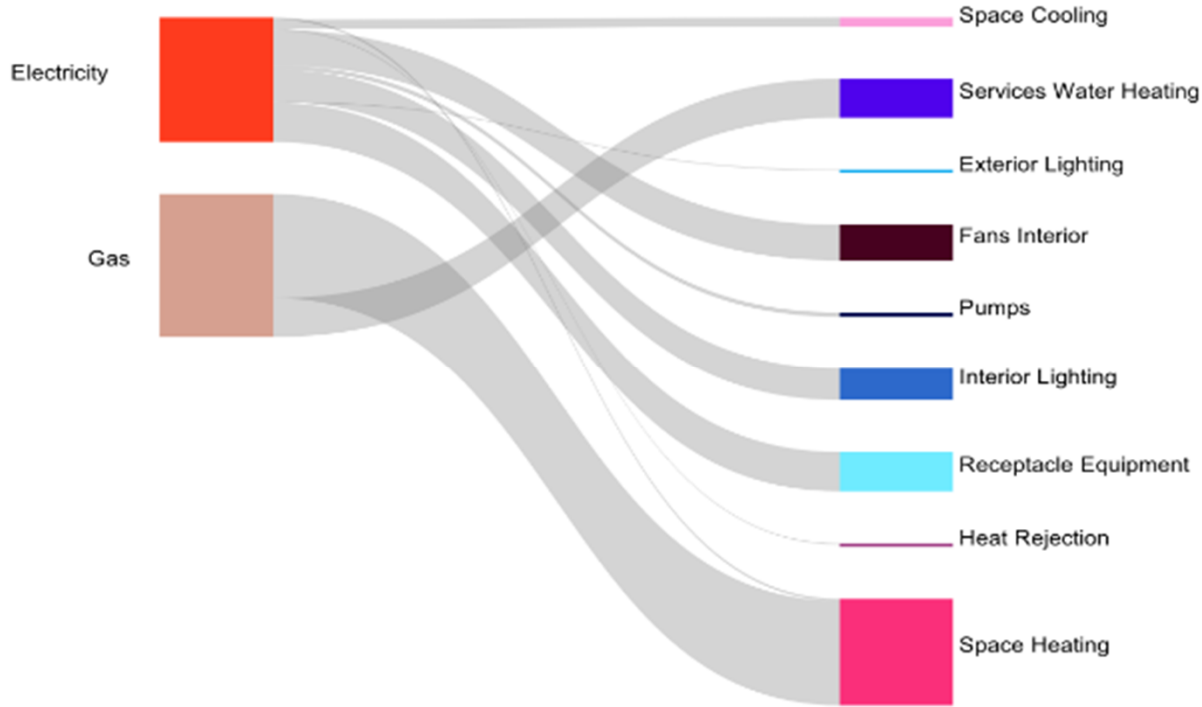
- ❑ RCM 1 – Lighting Upgrades
- ❑ RCM 2.1 – Boiler Replacements
- ❑ RCM 2.3 – AHU Heating Coil Valve and Pump
- ❑ RCM 2.4 – Heating Water Piping Replacement
- ❑ RCM 4 – BAS Optimization
- ❑ RCM 5 – Mechanical Equipment Replacement
- ❑ RCM 6 – BAS Upgrades
- ❑ RCM 8 – Building Submetering
- ❑ RCM 9 – Destratification Fans
- ❑ RCM 10 – Pool Evaporation Control

# Mini Dome

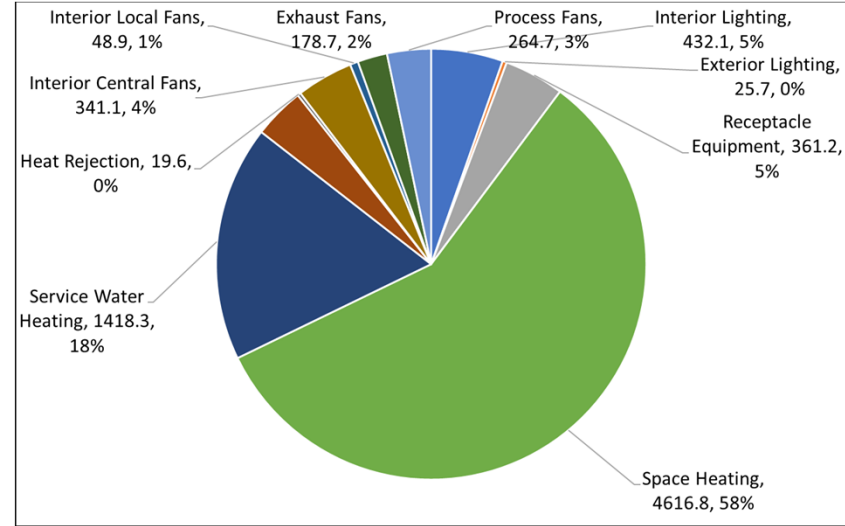


**140.0 62.2 kBtu/sf/yr**

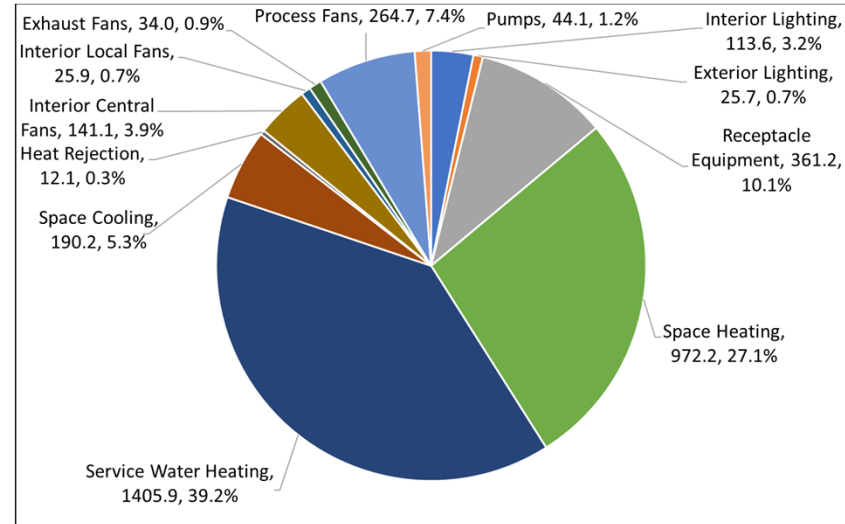
Energy Use Intensity Proposed model



# BASELINE



# PROPOSED



# Role of Building Energy Modeling



Quantitative Analysis: **Enhancing Building Energy Performance**

Building energy modeling **provides a quantitative analysis** of how different design decisions will impact the energy performance of the building.

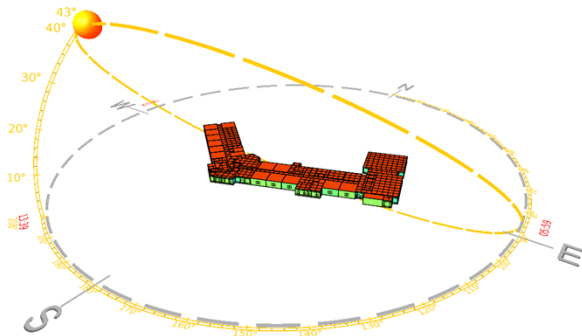
It can inform the **decision-making process and facilitate discussions** with stakeholders.

## Method 1 | ENERGY MODEL

~\$ 62,000

### Scope

- Model 5 buildings
- Develop Energy Management Plan for CBS compliance / Decarbonization
- Prioritize investment to meet EUI goals
- Built energy model for any future studies / upgrades



### Hours spent

300 hours  
~ 60 hours per  
school

## Method 2 | SPREADSHEET (EST)

### ROM hours to estimate energy savings

40 hours

### Estimated hours for 30 measures

1200 hours

\$250,000

→ **Approximately 4X more  
than energy modeling**

### Cost underestimate

ROM hours of 40 hours to develop spreadsheet for each measure is probably underestimated.

### Single-use

Because projects vary, spreadsheet must adapt, and the time spent developing them can increase.

### Unreliable

Accuracy is not guaranteed.

## Conclusion

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**Technological  
evolution of  
models**

**Importance  
attribute for a  
model – accuracy**

**A good model  
offers more than  
accurate prediction**

- breaking barriers
- linking buildings to place
- connecting with community

## Questions? Let's Connect!



**David Park, Ph.D, PE, CEM, BEMP**  
[dlpark@umci.com](mailto:dlpark@umci.com) | [in davidlpark](https://www.linkedin.com/in/davidlpark)

Every. Single. Energy savings. Matters! David couples analysis with energy audits to identify energy efficiency measures (EEMs) that are cost effective for owners' business goals. Driven to make a significant impact towards carbon reduction and sustainability, David enjoys studying and analyzing how building energy reduces utility and operational costs, making it a great investment for the future.

**Hailee Hammerquist, LEED Green Associate**  
[hhammerquist@umci.com](mailto:hhammerquist@umci.com) | [in hailee-hammerquist](https://www.linkedin.com/in/hailee-hammerquist)

Hailee is detail oriented, organized, and passionate about sustainable design. She loves tackling the complexity of our projects to ensure all the pieces fit efficiently together inside high-performing exteriors. Coming from West Virginia, Hailee is excited to experience all the outdoor adventures that the Seattle area has to offer. She spends her time off the clock outside hiking in the summer and hitting the slopes in the winter.





# We Love a Good Puzzle



**PRECONSTRUCTION / SOLUTION  
DEVELOPMENT**



**BUILD**



**FACILITY SERVICES**



**BUILDING ANALYSIS +  
MODELING**



**ENERGY + ENVIRONMENT**



**MANUFACTURING**



**BUILDING AUTOMATION**

# Diversity, Equity & Inclusion (DEI)

## MISSION + VISION

UMC's DEI mission is to foster a culture that welcomes a diverse group of skills, perspectives, and experiences—and empowers individuals to succeed and grow.

We are committed to creating a workplace where everyone feels **safe, seen, valued, and heard.**

## THIS INCLUDES

Dedicating resources to ensure UMC is a safe place for all.

Supporting diverse trade partners and vendors so they can thrive.

Providing education opportunities around unconscious bias.

Establishing core actions and policies to retain talent.

Evaluating pay equity and promotion velocity data within UMC.

Continuous monitoring of the health of our DEI culture.

## UMC DEI COMMITTEE

